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The Distribution and Zonation of Intertidal Organisms in Bass Strait

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INTRODUCTION

General accounts of the intertidal ecology of the Victorian and Tasmanian rocky coasts exist, (Bennett and Pope 1953, 1960), but the Bass Strait islands have been largely ignored. The only papers on the intertidal biota of Bass Strait islands which give more than species lists are those of Guiler et al. (1958) and Gillham (1965) on the intertidal ecology of Fisher Is., Saenger (1967) on the littoral plants of Flinders Is., and the brief mention of some Bass Strait islands in Bennett and Pope (1960).

The aim of the present work is to provide a detailed descriptive account of some aspects of the intertidal ecology of the Bass Strait islands, and to summarize the existing data on environmental conditions.

The data are assembled as descriptions of the intertidal zonation, and the sublittoral zones receive scant attention. The terminology adopted is that of Lewis (1961) and zones are established on biological criteria only. No attempt is made to correlate zones of organisms with tidal levels.

In this account the major emphasis is on ecologically important species and particularly those which are part of the zonation pattern. A representative collection of intertidal barnacles and molluscs has been lodged in the National Museum of Victoria. Algae are incorporated in the herbarium of the Melbourne University Botany School (MELU).

ENVIRONMENTAL CONDITIONS.

Waves

The objective measurement of wave action is seemingly impossible. Attempts have been made to place the measurement of turbulent water motion on a quantitative basis (Lewis, 1968) but such methods are of little use in broad scale ecological surveys where localities may be visited only once or twice and even then only under favourable weather conditions. It is also probable that maximum, and possibly even minimum, conditions of wave action will override general conditions.

In an attempt to clarify terms used in their work on Tasmanian shores, Bennett and Pope (1960: 221) proposed a set of descriptions of degree of 'exposure' and I have used their terms. Where field trips to a locality have been of short duration, assessment is made on personal observations. The presence and absence of some species has also influenced my assessment although I am well aware of the logical inconsistency involved in such an approach i.e. that the species occur on a shore because of the degree of wave action, and that the shore must be subjected to a certain degree of wave action because it has these species. Before a species can be used as a reliable indicator organism for wave action it must be shown that the species is responding only to that factor. The presence of *Cellana solida* (Blainville) is usually indicative of local shelter on coasts of maximal and sub-maximal wave action. Observations on Curtis Is. indicate that the limiting factor is not the degree of wave action in open positions but is perhaps the distribution of barnacles which is in turn dependent on substrate.

Rough seas are common in W. Bass Strait as winds from the W. and SW. have a long fetch over open ocean. Cape Bridgewater, W. Victoria, is accepted as a standard maximum for wave action (Bennett and Pope, 1953). Wave conditions on the W. coast of King Island are maximal but less severe than on the W. Victorian coast. The northern coast of Tasmania is sheltered from oceanic conditions and is classified as sheltered open coast. The E. Bass Strait islands range up to the submaximal wave action category although where the coast plunges steeply into deep water, e.g. Curtis Is., maximal wave action is encountered.

Tides

Tides in Bass Strait are mostly semidiurnal in nature with a marked diurnal inequality while tides along the north coast of Tasmania are semidiurnal. tidal range varies from approximately 1 m in W. Bass Strait to approx. 2·5 m in the E. Bass Strait islands. This maximum range of tide

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corresponds to the region where there is the greatest reduction in both the depth and width of Bass Strait.

Currents

Studies on current systems in SE. Australia have concentrated largely on the E. Australian seaboard and in the W. Bass Strait area. Currents have a marked influence on temperature distribution but can also be important in the distribution of planktonic larval forms. CSIRO studies in W. Bass Strait have been concerned with the distribution of crayfish larvae (Vaux & Olsen, 1961).

Bass Strait water is thought to come from three main sources (Newell, 1961). Using the terminology proposed by Rochford (1957) these are: (i) 'East Australian Current' waters—subtropical waters of high chlorinity and temperature originating from sources to the N. and E., (ii) Subantarctic waters—cold and low chlorinity waters traced to the circumpolar west wind drift, (iii) high chlorinity N. Bass Strait waters thought to be derived from the Spencer and St. Vincent Gulf area. Wyrtki (1960) shows the main features of surface water movements in the E. Australian region including Victoria and Tasmania. The essential feature is the general flow W. to E. in the southern portion. The pattern develops in response to the westerly winds and the obstruction caused by the Tasmanian land barrier. Along the E. Australian seaboard there is a general N. to S. flow, the 'East Australian Current'. The structure of the current is outlined in Hamon (1961, 1965), and Boland and Hamon (1970). Highley (1967) reviews ocean circulation off the E. coast of Australia.

Newell (1961) suggests that the effect of warm E. coast waters is felt in Tasmania as far south as 40°S. Hamon (1961, 1965) shows that the 'East Australian Current' turns away from the coast at approximate latitude 33°-34°S but in autumn under the influence of strong NE. winds may extend as far as Eden, 37°S. Highley (1967) suggests that eddy systems breaking off from the 'East Australian Current' are responsible for the transport of warmer E. coast water as far south as Tasmania. It is likely that this influence of warmer water could extend to the E. Bass Strait islands although the temperature distribution maps of Newell (1961) do not show this. CSIRO data for the period Jan.-April 1971 (*Aust. Fish. 31* (7) July 1972: 31) show the influence of the East Australian Current extending across Bass Strait during an atypical season.

Vaux and Olsen (1961) and Newell (1961) show the drift of surface waters in W. Bass Strait in the basis of drift bottle recoveries, Fig. 1.

There appears to be a reasonable correlation between these results and the wind pattern for the W. Bass Strait region. The presence of a north flowing surface current along the W. coast of Tasmania is not shown by Wyrtki (1960) except for March. The presence of such a water movement may be part of the explanation for the occurrence of colder summer waters in the W. Bass Strait region.

Dannevig (1915) postulates an oscillating body of water offshore from the N. Tasmanian coast. He considers that flood tides enter Bass Strait

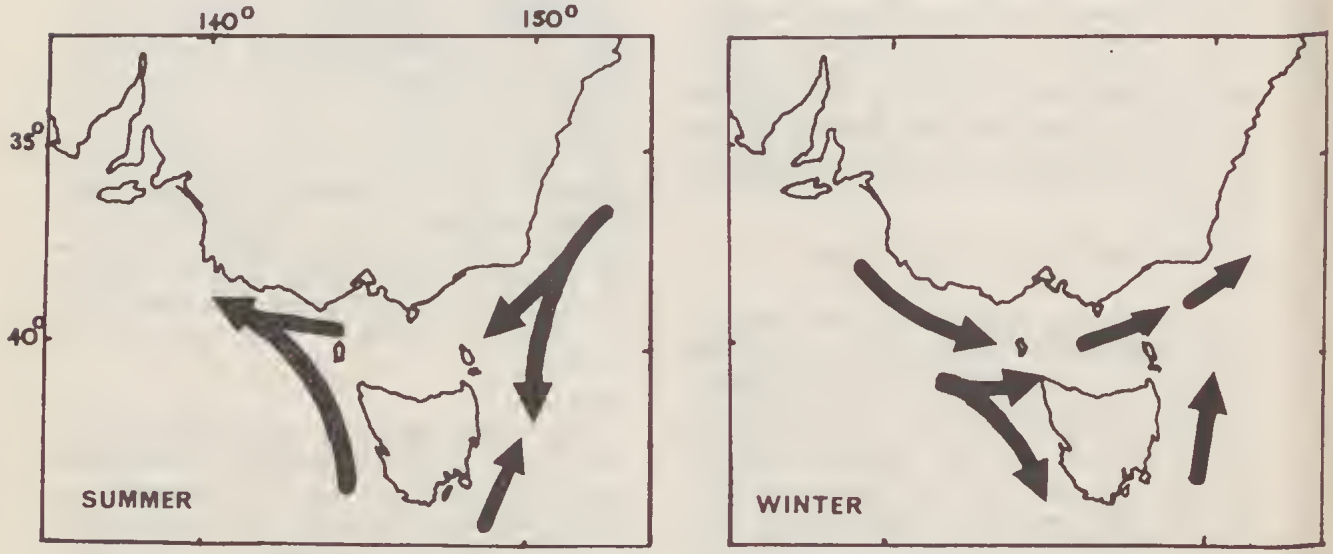


Fig. 1—Movement of surface waters as indicated by drift bottle recoveries (after Vaux and Olsen, 1961).

from both the E. and W., and tide ebbs back through both ends of the Strait. This concept is supported by Pollock (1971). Using predicted tidal data, Pollock constructed co-tidal diagrams for S.E. Australia. These show a variable pattern but the essential feature is the presence of two co-tide lines representing the same time and running N-S. at each end of Bass Strait. Pollock suggests that this is due to wave fronts entering Bass Strait from both the E. and W. These would interfere with each other to form a stationary wave and interchange of water between Bass Strait and the open water would be restricted.

Winds

Winds throughout Bass Strait are predominantly from the western sector, but in summer there is a strong southerly component in W. Bass Strait. SE. gales affect the eastern portion of the Strait at infrequent intervals particularly in autumn. The predominant wind direction affects height of waves and gives an indication of the direction of rough weather but frequently local topography is an overriding factor.

Sea-water Temperatures

Sea-water temperatures along the southern Australian coast are summarized in the charts of the Royal Netherlands Meteorological Institute (1949). More recent data for the Bass Strait region collected by the CSIRO Division of Fisheries and Oceanography, are summarized in a number of publications.

Newell (1961) collates CSIRO data for the period 1938-59 but plots this for summer (November-March) and winter (May-September) and his data are therefore not directly comparable with other data. Since he does not list data for both the warmest and coldest month this information cannot be used to classify the area in terms of temperature regimes.

Hynd and Robins (1967) summarize CSIRO data for the years 1957-62 inclusive (except 1959) for SE. South Australia, W. Victoria and Tasmania.

Vaux (1970) presents all CSIRO data for the period 1961-65. These show clearly the concentration of temperature records in areas which are of importance to the commercial fishing industry.

The temperature data for Bass Strait show a summer range of 16-19°C and a winter range of 11-13°C. Sea temperatures in E. Bass Strait are influenced by the 'East Australia Current' and are generally 2-3°C higher than those in W. Bass Strait. Temperature data from Vaux (1970) suggests that the influence of the 'East Australia Current' is variable depending on the extent of its southern movement in different years.

The Dutch charts show the presence of cooler waters during summer in SE. South Australia and W. Victoria. Hynd and Robins (1967) provide evidence of a cold water upwelling for the area Kingston, South Australia to Portland, Victoria. Their temperature graphs show that the range of summer temperatures is wide and that the lowest summer temperature is about the same as the lowest winter temperature. Lower summer temperatures appear to be a permanent feature of this area of coast and temperatures are often 1°C or more lower than those of Bass Strait waters. Besides this upwelling of colder waters there is evidence to suggest summer surface water drift from colder waters off W. Tasmania.

Knox (1963) outlines a classification of coastal waters which is applicable to Australia. Using his terminology the waters of Bass Strait would be regarded as cold temperate mixed waters although E. Bass Strait may in some years range into the transitional warm temperate category.

Table 1

Air temperature and relative humidity at stations around Bass Strait.
(*Australia, Bureau of Meteorology*, 1956)

Locality	*Average daily maximum temp.*		*Average daily minimum temp.*		*Average rel. humidity 1500 hrs.*	
	Jan.	*July*	*Jan.*	*July*	*Jan.*	*July*
Warrnambool	21·1	13·1	12·6	6·4	69	77
Cape Otway	19·9	12·6	13·1	7·8	69	75
Wilsons Promontory	19·3	12·2	13·8	8·7	77	82
Eddystone Point	20·4	12·8	12·7	6·8	64	77
Stanley	20·0	11·9	12·1	6·5	64	77
Currie, King Is.	19·8	12·8	12·0	7·7	69	85

FIG. 2—Map of the Kent Group showing localities and collecting sites mentioned in the text.

AIR TEMPERATURES AND RELATIVE HUMIDITY

No data are available which are directly relevant to the intertidal biota even for mainland coasts. Table 1 lists values for coastal localities around Bass Strait. As with wave action it may be extreme and freak conditions of temperature and relative humidity which are important in limiting species distributions.

EASTERN BASS STRAIT REGION: CURTIS AND DEAL ISLANDS

INTRODUCTION AND LOCATION

Curtis Is. (Lat. 39°28′, Long. 146°39′) is a steeply sloping island approximately 2 km long in a NNE. direction and about 1 km across. Field work was undertaken during the period 8.ii.71-15.ii.71.

Deal Is. (Lat. 39°29′, Long. 147°19′) is part of the Kent Group, Fig. 2.

Deal Is. is the largest of the Group and is approximately 6 km N.-S., 4 km E.-W. and 287 m at its highest point. Erith and Dover islands are separated from Deal Is. by Murray Pass which is approximately 2·5 km wide and 50-60 m deep. Prevailing weather conditions are from the W. and due to its irregular shape Deal Is. provides a wide range of habitat with regard to wave conditions.

Field work was undertaken during the following periods: 1.ix.68, 21.xi.69 to 25.xi.69 and 2.xii.69.

Coastal Geology and Topography

The islands of E. Bass Strait form part of the huge granite bathylith which extends from Wilsons Promontory (Victoria) to Eddystone Point (NE. Tasmania). On the two islands selected for detailed study (Curtis Is. and Deal Is.) the granite is typically coarse grained. Coastal formations range from steep plunging cliffs to broken rock and isolated boulders with a broad intertidal zone. Dune limestone occurs as a veneer on parts of Deal Is. particularly in the valleys, but it does not outcrop in the intertidal zone. As with other Bass Strait islands the slopes on the northern end are easier and sandy beaches occur at the head of the sheltered bays, East Cove and Garden Cove, on Deal Is.

Degree of Wave Action

Conditions of maximum wave action are encountered on Curtis Is. On Deal Is. 'Little Squally' Cove is open to weather from the S. and W. and represents the roughest water locality investigated. It is regarded as being submaximal-moderate wave action coast while the outer parts of both East and Garden Coves are moderate wave action coasts. Considerable local shelter is provided in the inner portion of these coves.

History of Algal Collecting

In December 1803 Robert Brown was a passenger on the colonial brig the *Lady Nelson* en route to Port Dalrymple, Tasmania, when it was detained in the Kent Group because of bad weather. While there Brown took the opportunity to engage in botanical collecting (Giblin, 1930). It is apparent that he revisited the Kent Group during early 1804 and in the appendix to Flinder's '*Voyage to Terra Australis*' Vol. 2, 1814, Brown states that he '. . . . repeatedly landed on Kent's Islands, in Bass Strait, on the shores of which the principal part of Submarine Algae contained in our collections were found' (Stearn, 1960). Brown collected relatively few algae in Australia, about 31 in all, and almost half were specimens from the Kent Group (Womersley, 1959). Most of Brown's specimens have only vague locations and are useless for determination of type localities (Burbidge, 1955); this is not so for his Kent Group specimens, and these islands are the type locality for a number of algae, including *Caulerpa brownii* (C. Agardh) Endlicher, *C. simpliciuscula* (Turner) C. Agardh and *Polyopes constrictus* (Turner) J. Agardh. In the report of the Victorian Field Naturalists' expedition to the Kent Group (Le Souef, 1891) no mention is made of algae although extensive collections were made of Bryozoa. Garreau (1958) in a general article about the Kent Group refers to the following algae: *Ulva lactuca Linnaeus, Hormosira banksii* (Turner) Decaisne and *Phyllospora comosa* (Labillardière) C. Agardh. He states that the bull kelp *Durvillea potatorum* (Labillardière) Areschoug is common, attaining lengths of 25 ft (approximately 8 m). This appears to be incorrect as no *Durvillea* occurs on the island.[1] His reference probably applies to *Macrocystis angustifolia* Bory.

The only recent documented records of algal collecting in the Kent Group are those from Deal Is. by Bennett and Pope in connection with their survey of Tasmanian shores (Bennett and Pope, 1960).

[1] Species absences should always be regarded with caution but since *Durvillea* is so conspicuous and characteristic it could scarcely have been missed.

Zonation

(i) Maximal wave action. (Curtis Is.).

The limit of the littoral zone is regarded as the upper limit of *Melarapha unifasciata* (Gray). Above this there is a black band of *Verrucaria* and above this a poorly developed band of the orange lichen *Caloplaca murorum* (Acharius) Th. Fries merges with the land vegetation.

(a) *Littoral Fringe:* This zone extends 2-3 m vertically and is characterized by *Melarapha unifasciata. Melarapha* is almost entirely restricted to crevices where it occurs in groups of up to about twenty individuals. These individuals are large, commonly about 1 cm in length. On flatter and smooth rock surfaces the blue-green alga *Calothrix crustacea* Bornet et Flahault forms a dense black slippery mat. *Lichina confinis* (Müller) C. Agardh is present in sheltered positions. The upper limit of the barnacles is quite distinct and only a few isolated *Chthamalus antennatus* Darwin occur in the lower part of the littoral fringe. Both *Melarapha unifasciata* and *Lichina confinis* overlap widely with the upper eulittoral.

(b) *Upper Eulittoral Zone:* The upper eulittoral is marked by the presence of the barnacles *Chthamalus antennatus* and *Chamaesipho columna* (Spengler). *Chthamalus* is restricted to the top of the zone whereas *Chamaesipho* has a broad overlap with *Catophragmus polymerus* Darwin of the mid-eulittoral. The barnacles cover the rock densely with approximately 3200 individuals per m^2 under rough water conditions. *Chamaesipho* occurs as isolated individuals or small patches and not in broad sheets as it does at Wilsons Promontory. With local shelter barnacles virtually disappear. *Melarapha unifasciata* is common in upper parts of this zone while *M. praetermissa* May occurs in sheltered parts.

Siphonarian limpets are common, particularly

Siphonaria diemenensis Quoy et Gaimard which occurs on open rock down to the mid-eulittoral. *S. tasmanica* (Tenison Woods) characteristically occurs in groups in crevices and on steep faces and *S. funiculata* Reeve is found in crevices and crevice pools. *Notoacmea petterdi* (Tenison Woods) is typical of vertical rock faces and extends into the littoral fringe. A number of animals are restricted to crevices, such as the mussels *Modiolus pulex* (Lamarck) and *Mytilus planulatus* (Lamarck) and the barnacle *Tetraclita purpurascens* (Wood), while others including the limpets *Patellanax peroni* (Blainville), *Patelloida alticostata* (Angas), *P. latistrigata* (Angas), and occasionally small *Dicathais textilosa* (Lamarck) are found in crevices but also occur on open rock faces at lower levels or with shelter. *Cellana solida* is found at this level and lower.

Algae are not as conspicuous as animals at this level. *Bangia fuscopurpurea* (Dillwyn) Lyngbye occurs in the uppermost part of this zone particularly on steep rock faces. *Porphyra columbina* Montagne occurs scattered throughout lower parts and into the mid-eulittoral zone. The *Porphyra* during the study period was poorly developed perhaps due to seasonal growth. Both *Bangia* and *Porphyra* are absent from sheltered positions. *Enteromorpha* is characteristic where there is freshwater seepage.

Where protection is afforded by large inshore boulders *Austrocochlea concamerata* (Wood), *Cellana solida, Melanerita melanotragus* (A. E. Smith), the starfish *Patiriella calcar* (Lamarck) and *P. exigua* (Lamarck) are common. *Tetraclita purpurascens* becomes abundant in crevices and the crab *Leptograpsodes octodentatus* (Milne-Edwards) is present.

(c) *Mid-Eulittoral Zone:* In rough water areas this zone is dominated by a dense band of *Catophragmus polymerus* which almost entirely covers the rock. The brown alga *Splachnidium rugosum* (Linnaeus) Greville forms a prominent band in the lower regions (Pl. 10, Upper) except on steep rock faces. The *Splachnidium* plants are small (to 3 cm high and 4 mm wide), and are epizoic on *Catophragmus* as at Wilsons Promontory. Above the *Splachnidium,* and extending to the lower parts of the upper eulittoral, are the following algae; *Nemalion elminthoides* (Velley) Batters sometimes epiphytic on *Cellana solida, Porphyra* and *Rivularia firma* Womersley. *Chaetangium fastigiatum* (Bory) J. Agardh occasionally forms a conspicuous band on flat surfaces but is otherwise scattered; in upper parts of the zone it is severely desiccated. *Patelloida alticostata* is scattered above the *Splachnidium* and *Patelloida latistrigata* is common throughout the zone (over 1,500 individuals per m^2). The red anemone *Actinea tenebrosa* Farquhar is abundant in crevice pools.

In sheltered regions the barnacles and algae are absent and the zone is almost bare with a few *Patelloida alticostata, P. latistrigata, Siphonaria diemenensis* and *S. tasmanica.*

(d) *Lower Eulittoral Zone: Balanus nigrescens* Lamarck is the most conspicuous animal at this level and in rough water parts entirely covers the rock. The barnacles are of the tall growth form up to 6 cm high. Older specimens commonly have 10 (-30)smaller individuals epizoic so that a thick crust of barnacles is built up on the rock surface.

The *Balanus* is heavily covered with epiphytic *Corallina officinalis* Linnaeus, *Dasyopsis clavigera* Womersley, *Polysiphonia*[1], and *Sphacella ferruginea* (Harvey) Womersley. *Asparagopsis armata* Harvey is restricted to regions where there is regular wave wash. Encrusting lithothamnia entirely cover the *Balanus.* On flat pockets low in this zone *Xiphophora chondrophylla* (R. Brown ex Turner) Montagne ex Harvey, completely replaces the *Balanus.* Molluses are uncommon at this level with *Patellanax peroni* and *Poneroplax albida* (Blainville) (up to 71 mm in length) on open surfaces and *Dicathais textilosa* in crevices. The tetrasporic stage of *Asparagopsis, Falkenbergia rufolanosa* (Harvey) Schmitz is commonly epizoic on *Poneroplax.*

In sheltered areas *Balanus* is replaced by a coralline algal zone with lithothamnia covering the rock. *Patellanax peroni* is the only animal recorded.

[1] This species is the same as recorded by Womersley (1950 p. 184) as *P. dasyoides* Zan. Womersley (pers. comm.) states it is, however, not Zanardini's species but an undescribed one.

(e) *Upper Sublittoral Zone:* There is no fringing zone of organisms referable to a sublittoral fringe, and the demarcation of the sublittoral is taken as the upper limit of the large brown algae. The nature of the coastline prevents close examination of this area. In roughest water places the dominant alga in the visible sublittoral is *Phyllospora comosa. Cystophora moniliformis* (Esper.) Womersley et Nizamuddin also occurs and comparatively rarely *Macrocystis angustifolia* and *Ecklonia radiata* (C. Agardh) J. Agardh. Where *Phyllospora* is in the 'suck back' region, plants are stunted and possess few laterals. In calmer water places *Gelidium glandulaefolium* Hooker et Harvey is subdominant and occurs in dense patches. Occasionally *Balanus nigrescens* with *Dasyopsis clavigera* and *Polysiphonia* extend into this zone.

In most sheltered positions *Perithalia caudata* (Labillardière) Womersley becomes dominant with

epiphytic *Perithamnion dispar* (Harvey) Wollaston. Other species include *Asparagopsis armata, Ballia callitricha* (C. Agardh) Kuetzing, *Laurencia elata* (C. Agardh) Harvey, *Plocamium angustum* (J. Agardh) Hooker et Harvey and *Pterocladia capillacea* (Gmellin) Bornet et Thuret. *Dicathais textilosa* may be abundant under these conditions.

(f) *Pool Flora:* Pools in the mid and lower eulittoral are generally small and shallow, with lithothamnia covering the rock surfaces and no other conspicuous plant life. Occasionally well sheltered pools are formed under boulders. Species found in such pools include *Chaetomorpha aerea* (Dillwyn) Kuetzing, *Chaetomorpha darwinii* (Hooker) Kuetzing, *Cladophora feredayi* Harvey, *Bryopsis gemellipara* J. Agardh, *Ulva lactuca, Dictyota dichotoma* (Hudson) Lamouroux, *Amphiroa ephedraea* (Lamouroux) Areschoug, *Ballia callitricha, Centroceras clavulatum* (C. Agardh) Montagne, *Ceramium, Champia compressa* Harvey, *Cheilosporum sagittatum* (Lamouroux) Areschoug, *Phitymophora antansioides* (Sonder) Womersley, *Polyporolithon patena* (Hooker et Harvey) L. R. Mason, *Polysiphonia* and *Pterocladia capillacea.* In lower pools the brown algae become dominant: *Cystophora moniliformis* (with epiphytic *Corynophloea cystophorae* (J. Agardh), *Ecklonia radiata, Macrocystis angustifolia, Phyllospora comosa* and *Xiphophora chondrophylla* (with epiphytic *Portphillipia australis* (J. Agardh) Silva).

(ii) Submaximal-moderate wave action, ('Little Squally' Cove, Deal Is.)

At the head of the cove the intertidal area is a boulder beach strewn with jetsam. South of this area the coastline is of broken granite masses below almost vertical cliffs up to 250 m. The orange lichen *Caloplaca murorum* occurs on the cliff face and the sparse vegetation at this level is mainly *Stipa teretifolia* Steudel, *Carpobrotus rossii* (Haworth) Schwantes, *Disphyma australe* (Solander) J. M. Black and *Calocephalus brownii* (Cassini) F. Mueller.

(a) *Littoral Fringe:* A prominent band of *Verrucaria* marks the littoral fringe. *Melarapha unifasciata* occurs in the lower part of the zone and occupies a vertical range of approximately 3m. *M. praetermissa* occurs at this level but extends into the upper eulittoral zone. *Melanerita melanotragus* and *Lichina confinis* are restricted to areas protected from direct wave action both in the littoral fringe and the upper eulittoral zone. The crab, *Leptograpsus variegatus* (Fabricius) is common amongst boulders.

(b) *Upper Eulittoral Zone:* This zone is relatively bare and is marked by the barnacle *Chthamalus antennatus,* and the honeycomb barnacle *Chamaesipho columna* which extends into the mid-eulittoral zone. *Melarapha praetermissa* occurs particularly in crevices. *Enteromorpha* is typical of positions where freshwater seepage occurs.

(c) *Mid-Eulittoral Zone:* The surf barnacle, *Catophragmus polymerus,* is characteristic of the zone. *Cellana solida* is best developed in this zone although it occurs both above and below this level. *Modiolus pulex, Patelloida latistrigata* and *Siphonaria diemenensis* occur at this level but the *Modiolus* is restricted to crevices. Occasionally *Rivularia firma* and *Porphyra columbina* are found in the upper part of the zone. *Splachnidium rugosum* forms a conspicuous band with the uppermost individuals dying off. Price (1966) makes a similar observation at Leonards Bay, Wilsons Promontory where young *Splachnidium* plants develop throughout the *Catophragmus* belt but as the summer approaches the *Splachnidium* band becomes narrower.

(d) *Lower Eulittoral Zone:* This zone is relatively bare on steep faces with stunted corallines and *Ulva lactuca* in the crevices. *Asparagopsis armata* and *Poneroplax costata* (Blainville) are common although *Poneroplax costata* is not recorded east of Wilsons Promontory on the mainland coast.

Where boulders and broken rock shelter this zone from wave action *Hormosira banksii* and *Gelidium pusillum* (Stackhouse) Le Jolis are common. *Cellana solida* occurs, often with epizoic *Scytosiphon lomentaria* (Lyngbye) Link. *Cominella lineolata* (Lamarck) is recorded from this zone. Pools at this level have a flora similar to that recorded in sheltered parts of the upper sublittoral zone.

(e) *Upper Sub-Littoral Zone: Phyllospora comosa* is the dominant alga visible in the sublittoral zone but in sheltered parts there is a clearly defined band, 10-15 cm vertical range, of *Xiphophora chondrophylla* above the *Phyllospora.* This *Xiphophora* band is emergent for several hours during periods of low water spring tides and is a common feature of zonation on the island, (Pl. 10, Lower). It is interpreted as sub-littoral for two main reasons:

The species which occur as sub-dominants in this zone are primarily subtidal and although the upper limit is clearly defined some individuals of *Xiphophora* do extend well below the fringing band. The species associated with *Xiphophora* are *Cystophora moniliformis, Leathesia difformis* (Linnaeus) Areschoug, *Sargassum* species, *Corallina officinalis, Haliptylon subulata* (Ellis et Solander) Johansen and small *Laurencia* species.

Where both *Xiphophora* and *Cystophora*

torulosa (R. Brown ex Turner) J. Agardh occur together at Deal Is. the *Xiphophora* band lies below the *Cystophora torulosa*. In Victoria and Tasmania *C. torulosa* forms a distinct lower subzone of the lower eulittoral zone. The occurrence of a dense band of *Xiphophora chondrophylla* at this level is not a common feature of E. Bass Strait islands although it is characteristic of sheltered open coast on King Is. *Xiphophora gladiata* (Labillardière) Montagne ex Kjellman occupies a similar position on sheltered and semi-sheltered Tasmanian mainland shores.

The subtidal rock surfaces are entirely covered with encrusting lithothamnia. Species commonly associated with *Phyllospora comosa* include *Ballia callitricha, Gelidium australe* J. Agardh, *Laurencia elata, L. filiformis* (C. Agardh) Montagne and *Plocamium angustum*. Other species recorded in this zone include *Bryopsis plumosa* (Hudson) C. Agardh, *Dictyota dichotoma, Halopteris pseudospicata* Sauvageau, *Perithalia caudata* and *Phacelocarpus labillardieri* (Turner) J. Agardh.

The outer parts of both East Cove and Garden Cove, sites A and B, Fig. 2, are classified as areas of moderate wave action. The zonation pattern is similar in most respects to that at 'Little Squally' Cove. The main differences are:

The presence of *Balanus nigrescens* in the lower eulittoral zone;

Actinea tenebrosa and *Tetraclita purpurascens* are present but confined to crevices; and

At site A where the granite cliffs fall almost vertically into the sub-littoral the only algae visible in the upper sub-littoral zone are *Macrocystis angustifolia* and *Phyllospora comosa*.

(iii) Moderate-sheltered open coast. (East Cove and Garden Cove, Deal Is.)

East Cove and Garden Cove both provide a range of environment from moderate wave action,

TABLE 2

Distribution of important zone forming organisms in East Cove, Deal Is., E. Bass Strait.

Degree of wave action	Moderate with strong tidal scour.	Sheltered open coast	Extreme sheltered open coast
Locality	East Cove, site A	East Cove, site C	East Cove, site D
Nature of substrate	Steep sloping granite	Gently sloping granite (30° - 70°)	Broken granite and boulders with sand in the sub-littoral zone.
Littoral fringe	Verrucaria Melarapha unifasciata M. praetermissa	Melarapha unifasciata M. praetermissa	Melarapha unifasciata
Upper eulittoral zone	Cellana solida Chamaesipho columna Chthamalus antennatus Patelloida latistrigata Siphonaria diemenensis Siphonaria funiculata	Cellana solida Chamaesipho columna Patelloida alticosta Patelloida latistrigata Siphonaria diemenensis	Scytosiphon lomentaria Cellana solida Melanerita melanotragus
Mid-eulittoral zone	Porphyra columbina Splachnidium rugosum Catophragmus polymerus Cellana solida Chamaesipho columna	Porphyra columbina Rivularia firma Cellana solida Chamaesipho columna	Celidium pusillum Cellana solida Caleolaria caespitosa (occasional)
Lower eulittoral zone	Corallina officinalis Balanus nigrescens Poneroplax costata	Corallina officinalis Hormosira banksii	Corallina officinalis Hormosira banksii Laurencia botryoides Ulva lactuca Cellana solida
		Colpomenia sinuosa Cystophora torulosa	Colpomenia sinuosa Cystophora torulosa Leathesia difformis
Upper sub-littoral zone	Macrocystis angustifolia Phyllospora comosa encrusting lithothamnia	Xiphophora chondrophylla Caulerpa species Ecklonia radiata & mixed Fucales	Caulerpa brownii Posidinia australis & epiphytes

e.g. site A, to extreme sheltered open coast, e.g. site D. Table 2 outlines the basic pattern observed in East Cove.

General Observations on the Marine Biota of Eastern Bass Strait.

(i) Under rougher water conditions the algae associated with the dominant large brown algae of the upper sub-littoral zone are predominantly Rhodophycean whereas the Phaeophyta and Chlorophyta are better represented in sheltered localities. Species found with *Macrocystis angustifolia* and *Phyllospora comosa* include *Halopteris pseudospicata, Amphiroa anceps* (Lamarck) Decaisne, *Gelidium australe, Laurencia elata, L. filiformis, L. heteroclada* Harvey, *Plocamium angustum, P. cartilagineum* (Linnaeus) Dixon and *P. costatum* (C. Agardh) Hooker et Harvey. In sheltered positions where *Ecklonia radiata* becomes dominant, (often with *Xiphophora chondrophylla* as a sub-littoral fringe), the number of species visible in the sub-littoral zone is increased. Species present include *Caulerpa brownii, C. geminata* Harvey, *C. vesiculifera* Harvey, *Acrocarpia paniculata* (Turner) Areschoug, *Caulocystis cephalornithos* (Labillardière) Areschoug, *Cystophora moniliformis, C. subfarcinata* (Mertens) J. Agardh, (vesiculate form), *Dictyota dichotoma, Pachydictyon paniculatum* (J. Agardh) J. Agardh, *Phyllospora comosa, Sargassum* species (infertile), *Corallina officinalis, Plocamium angustum, P. cartilagineum,* and *Pterocladia capillacea. Portphillipia australis* is a common epiphyte on *Xiphophora.*

(ii) Barnacles on open rock are characteristic of rougher water areas. *Balanus nigrescens* and *Catophragmus polymerus* occur only where there is at least moderate wave action while *Chamaesipho columna* and *Chthamalus antennatus* are more tolerant of shelter. *Tetraclita purpurascens* is an exception to this preference for rough water conditions and it is confined to shaded crevices.

(iii) *Cellana solida* is a conspicuous mid-eulittoral organism occurring, as in Tasmania, at the bases of boulders on the inner part of the shore and at lower levels in sheltered sites. On Curtis Is. *C. solida* also occurs occasionally on open rock faces where it is subjected to extreme wave action. Individuals from the inner shore are generally smaller, 40 (28-50) mm in length (32 measurements), than those from outer positions, 53 (41-84) mm in length (21 measurements).

The difference between sizes on sheltered and open rock may be due to a number of factors, such as the relative ease of physical removal of small individuals from open rock face by direct wave action or by predation from oyster catchers.

Under rough water conditions *Cellana* appears to be favoured where there are aplite intrusions in the granite. On the smooth aplite barnacle numbers are reduced (Table 3).

It is therefore possible that the preference for inshore positions generally shown by *Cellana* may be due to competition from organisms such as barnacles which are favoured on rough water outer parts. Guiler et al. (1958) have made a similar suggestion to account in part for the absence of *C. solida* from south point on Fisher Is.

(iv) Where *Patelloida latistrigata* and *P. alticostata* occur at the same site the latter appears to favour sheltered positions.

(v) *Melanerita melanotragus* is not a reliable zonal indicator as it has a marked tidal periodicity in its activity (Guiler et al., 1958). It is however, an indicator of sheltered positions on open coast.

(vi) *Hormosira banksii* and *Cystophora torulosa* are two reliable zonal indicators for the lower eulittoral zone in sheltered localities. Both are less common in rough water areas where they are restricted to crevices. Algae such as *Splachnidium rugosum* and *Porphyra columbina* occur only in rough water positions.

(vii) *Galeolaria caespitosa* Lamarck occurs only in sheltered positions. *Actinea tenebrosa* is common at all levels in such places but with increase in wave action is confined to crevices and crevice pools in the upper and mid-eulittoral zones.

(viii) Under moderate wave conditions the species composition of the lower eulittoral zone is dependent on the slope of the rock surface. On gently sloping faces algae are dominant and include *Asparagopsis armata, Ceramium, Champia* and young, stunted *Laurencia* species. *Liagora harveyiana* is recorded from this zone. On steep rock faces there are fewer algae and the rock is covered with encrusting lithothamnia with *Balanus nigrescens* and *Poneroplax costata* the only conspicuous animals.

(ix) Where the upper sub-littoral zone is sand with occasional rock and is very sheltered *Posidonia australis* Hooker occurs with epiphytic *Myriogloia sciurus* (Harvey) Kuckuck, *Caulerpa brownii* is common on rock, and in Garden Cove

Table 3

Density of Barnacles and *Cellana solida* (number of individuals per 25 cm^2) on granite and aplite, mid-eulittoral zone.

	Catophragmus polymerus	*Chamaesipho columna*	*Cellana solida*
Aplite	75	47	20
Granite	150	120	0^{-3}

Dictyopteris acrostrichoides (J. Agardh) Boergesen is also found.

(x) *Bryopsis vestita* J. Agardh is abundant in East Cove, Deal Is., where sand covers the rock in the mid and lower eulittoral zones. It is also found on the jetty piles.

(xi) A *Ralfsia-like* crust occurs in patches on rock surface throughout the mid-eulittoral zone and on the shells of *Cellana solida.* No fertile material appears to be present.

Affinities of the Eastern Bass Strait Marine Biota

Plants. Almost all of the species recorded for E. Bass Strait are shared with both the Victorian and Tasmanian floras: only few are shared with either the mainland or Tasmania. *Caulerpa vesiculifera* is present on Deal Is. and on the Victorian coast but is not recorded for Tasmania. Womersley (1956) states that *C. vesiculifera* probably occurs on the N. Tasmanian coast but I have not found it there. *Macrocystis angustifolia* is present on the mainland coast and on Deal Is. and on Flinders Is. (Saenger, 1967). On the Tasmanian east coast the species present is *M. pyrifera* (Linnaeus) C. Agardh. Specimens from Waterhouse Is. and Swan Is. were obtained without holdfasts. Womersley (1954) has established that holdfast characters are the only reliable features to distinguish between *Macrocystis angustifolia* and *M. pyrifera* but the size of the mature lateral blades suggests that the species present in southern Bass Strait is *M. pyrifera.*

A number of species which occur in E. Bass Strait are not found on the New South Wales coast. These include the prominent zone forming cool temperate species *Cystophora torulosa* and *Xiphophora chondrophylla;* also *Ballia callitricha* and the siphonous green algae *Bryopsis vestita, Caulerpa brownii* and *C. longifolia* C. Agardh.

Floristically then, the E. Bass Strait islands are linked with Victoria and Tasmania. The limited data available requires that species' absences be regarded with caution. *Durvillea potatorum* is definitely absent and no satisfactory reason has been found to account for this. Sea temperatures in E. Bass Strait are certainly not the limiting factor since *Durvillea* extends to Tathra, New South Wales; substrate and degree of wave action are unlikely to control distribution as *Durvillea* occurs under similar conditions at Wilsons Promontory.

Animals. Most of the prominent zone forming animals of the E. Bass Strait islands are found on both the Victorian and Tasmanian coasts, but a few fail to bridge the Strait. *Balanus nigrescens* is common on Curtis Is. and present on Deal Is. but I have not recorded it further south. Guiler (1960a) suggests that it may be present on the NE. corner of Tasmania but I have not seen it there nor on Swan Is. or Goose Is. *Cellana solida* is a dominant eulittoral species in E. Tasmania and through the E. Bass Strait islands, and although it has been recorded for Wilsons Promontory (Macpherson and Gabriel, 1962) *C. tramoserica* (Sowerby) is the common species at this locality.

WESTERN BASS STRAIT REGION: KING ISLAND.

Introduction and Location

King Is. is approximately 58 km due S. (39° 35'S., 40°10'S.) and 21 km wide (143°51'E, 144°10'E.) and lies to the W. of the Bassian basin (Weeks and Hopkins, 1967). Prevailing weather conditions are from the W., and the N.-S. orientation of the island, coupled with the relatively shallow off-shore water on the eastern coast (Admiralty Map 404, King Is.), ensures a range of environmental conditions from maximal wave action to sheltered open coast.

Localities mentioned are shown in Fig. 3. Field work was undertaken from 28.v.71 to 31.v.71, and this should be kept in mind when comparing observations made here, with summer observations at E. Bass Strait localities.

Coastal Geology and Topography

Jennings (1959) has made a detailed study of the coastal geomorphology of King Is. Localities on the W. coast and at Naracoopa are on schists and quartzites of presumed pre-Cambrian age. The shore line consists of irregular rocky reefs which project up to 3 m or more above low tide. At Naracoopa the rocky reefs are truncated in upper regions by a sandy beach. Angular, steep sided rock pools are common.

The NE. coast, site 3, consists of low granite cliffs falling abruptly into shallow water. Occasionally the granite slopes gently or forms almost level shelves; pools are not common.

Degree of Wave Action

Conditions on the west coast are almost invariably rough and the least sheltered positions are rated as maximal wave action, site 2. Local conditions have a marked effect; near Currie, site 1, offshore rock mitigates wave action, and the locality is classified as submaximal wave action. Site 3 in the NE. of the island falls within the category of moderate wave action while Naracoopa, site 4, is regarded as sheltered open coast.

These assessments are made on both personal observations and information provided by local inhabitants, although it is obvious that the degree of wave action will vary with changing weather

FIG. 3—King Island showing localities and collecting sites mentioned in the text.

conditions. The rough water nature of the western coastline is illustrated by the huge quantities of drift weed, mainly *Durvillea potatorum,* which lies in decomposing heaps up to 1 m high. Campbell (1888) made a similar observation.

History of Algal Collecting

King Is. was discovered in 1798 but it was not until December 1802 that Lieutenant Robbins took formal possession for the British Crown. In April 1802 Robert Brown, on board the *Investigator,* spent several days on the island, but his journal makes no reference to the algae (see Willis and Skewes, 1955, for a transcription of R. Brown's journal).

In the report of the Victorian Field Naturalists' excursion (Campbell, 1888), Baron von Mueller lists all palnts recorded from the Island including those of R. Brown, as well as later collectors. This list includes Lycopophyta and Pterophyta but algae are not included, which again indicates that Brown did not collect algae on King Is.

In December 1802, Baudin in the corvette *Le Géographe* visited the island and Péron, the zoologist of *Le Géopraphe* made some mention of the algae. 'Tous les rivages étoient couvertes d'une grande quantité de fucus, qui, pour la plupart, formoient des espèces nouvelles; j'en décrivis plusiers sous les noms de *f. phyllotrichos,* de *f. caulitortus,* de *f. panacrochordus,* etc.: cette dernière paroît composée des petites verrues. Je retrouvai pareillement sur ces bords les fucus curieux que j'avois précédemment décrit sous le nom de *phyllophorus,* et le *f. gigantinus* présentoit aussi çá et là de puissans débris'. (Péron, 1824, vol 3: 21-22). Bennett suggests that *f. pana-*

Table 4

Distribution of important zone forming organisms on King Is., W. Bass Strait.

Degree of wave action	Maximal-submaximal	Moderate	Sheltered open coast
Region	West coast	North-east coast	East coast
Locality	Currie and Cape Wickham (sites 1 & 2)	1 ml. N.E. of Cape Wickham (site 3)	Naracoopa (site 4)
Substrate	Precambrian schists and quartzites	Granite	Precambrian schists and quartzites
Littoral fringe	Melarapha paludinella M. practermissa	Melarapha praetermissa	Lichina confinis Melanerita melanotragus Melarapha praetermissa
Upper eulittoral zone	Chamaesipho columna Notoacmea mayi N. petterdi Siphonaria diemenensis S. tasmanica	Lichina confinis Cellana tramoserica Chamaesipho columna Siphonaria diemenensis	Lichina confinis Austrocochlea constricta Bembicium nanum Cellana tramoserica Chamaesipho columna Siphonaria diemenensis Tetraclita purpurascens
Mid-eulittoral zone	Rivularia firma Cellana tramoserica Chamaesipho columna --- Corallina officinalis Pseudolithophyllum hyperellum	Rivularia firma Chamaesipho columna --- Gelidium pusillum Galeolaria caespitosa	Rivularia firma Cellana tramoserica Chamaesipho columna Galeolaria caespitosa
Lower eulittoral zone	lithothamnia Patellanax peroni Poneroplax species	Hormosira banksii Codium fragile Poneroplax species --- Cystophora torulosa	Hormosira banksii Laurencia tasmanica Cellana tramoserica Patelloida alticostata --- Cystophora torulosa
Upper Sub-littoral zone	Durvillea potatorum	Caulerpa brownii Cystophora moniliformis C. siliquosa & mixed Fucales Macrocystis angustifolia	Xiphophora chondrophylla --- Caulerpa brownii Cystophora moniliformis C. siliquosa & mixed Caulerpa species & Fucales

crochordus is *Hormosira banksii,* that *phyllophorus* may well be *Phyllospora comosa* and *f. giganticus* is *Durvillea potatorum* (Micco, 1971: Appendix E).

The only publication on King Is. algae this century appears to be a list of 32 algae collected by Mrs. Spong and identified by A.H.S. Lucas (Ewart, 1907). The McCoy Society for Field Investigation and Research visited King Is. during the 1930's but no report was issued. Algae were collected (Dr. A. Gale, pers. comm.), but no records or specimens have been located.

Zonation

Zonation is obscured by the dissected nature of the rocky shoreline. The zoning pattern is discussed for the different degrees of wave action and Table 4 summarizes the information for the major zone forming organisms.

(i) Maximal-submaximal wave action, (sites 1 and 2, West Coast).

Maritime zone organisms merge with the littoral fringe where there is no major environmental break at this level. Stokes Point, the southern extreme of the island, is a low spit approximately 7 m high and less than 200 m wide. This area is unprotected and is described as 'only a few feet high and looks like a group of boulders over which the sea is constantly breaking' (Victoria, Public Works Department, 1970). The vegetation on the spit is predominantly *Calocephalus brownii, Carpobrotis rossii* and *Disphyma australe. Parmelia* and *Caloplaca* occur on rocks across the headland but neither are particularly common. The marine isopod, *Ligia australiensis* (Dana) shelters under loose rock within 7 m of the shore and the crab, *Leptograpsodes octodentatus* is found at distances up to 20 m from high tide mark.

(a) *Littoral Fringe: Melarapha praetermissa* is the characteristic organism and occurs at levels up to 5 m above high tide mark, which corresponds to the upper limit of coastal rocks. It is abundant towards the lower limit of the zone and in positions of local shelter. *Melarapha paludinella* (Reeve) occurs on the outer edge and extends into the upper eulittoral zone. *M. unifasciata* is absent. *Notoacmea petterdi* and *N. mayi* May are found on vertical surfaces on the outer edge but *N. mayi* shows a preference for positions with flying spray. *Patelloida alticostata* and *Siphonaria tasmanica* reach this zone but only in crevices or as juveniles. *Lichina confinis* is more common in the upper eulittoral zone but isolated patches occur here. In high level pools on the outer edge *Enteromorpha,* corallines and encrusting lithothamnia are often found; some shallow pools have dense growth of *Scytosiphon lomentaria* with epiphytic *Giffordia irregularis* (Kuetzing) Le Jolis. These pools undoubtedly receive fresh-water inflow.

(b) *Upper Eulittoral Zone:* The upper limit of this zone is defined by the upper limit of the honeycomb barnacle *Chamaesipho columna.* This barnacle characterizes both the upper and mid-eulittoral zones with a coverage up to 40% and a vertical range of 2 m in open positions. It often, though not invariably, occurs in crevices formed by the differential weathering of the rock. *Tetraclita purpurascens* is the only other barnacle present and is rare and confined to deep sheltered crevices. Only four individuals were found at Cape Wickham in spite of a careful search for this species. *Lichina confinis* occurs in the uppermost part of this zone, particularly on the plates of *Chamaesipho. Lepsiella vinosa* Lamarck is found occasionally with the *Chamaesipho. Patelloida alticostata* and *P. latistrigata* are mainly confined to crevices while *Siphonaria diemenensis* and more rarely S. *tasmanica* occur on open rock face. *Notoacmea mayi* and *Melarapha paludinella* may become abundant at this level. Small individuals of *Cellana tramoserica*[1] occur throughout the zone except under conditions of extreme wave action.

On inner portions of the reef protected from direct wave action *Bembicium nanum* (Lamarck) and *Melanerita melanotragus* are locally abundant. *Austrocochlea constricta* (Lamarck) is common in shallow pools and *A. concamerata,* which is comparatively rare, is found around pool margins and in crevices.

Pools on the outer edge are characterized by *Chaetomorpha aerea, Enteromorpha, Colpomenia sinuosa* (Martens ex Roth) Derbès et Solier, occasional *Hormosira banksii* and *Jania fastigiata* Harvey; *Caulerpa obscura* Sonder occurs in dense patches entirely filling some pools. *Actinea tenebrosa* is common in pools and crevices throughout this and the next zone.

[1] The species collected appears to fall within the limits of *Cellana tramoserica.* However *C. solida* (as *C. limbata*) is the species recorded for King Is. in May (1924).

(c) *Mid-Eulittoral Zone:* The mid-eulittoral zone shows a downward extension of some species from upper zones. *Chamaesipho* is still common and *Cellana tramoserica* is more prominent with larger individuals (> 2-3 cm). The lower limit of this zone is marked by a dense band of *Pseudolithophyllum hyperellum* (Foslie) Adey and *Corallina officinalis* in open positions. With slight increase in shelter *Lithothamnion* covered *Galeolaria caespitosa* becomes dominant. Both the *Pseudolithophyllum* and the *Galeolaria* grow so

thickly that they virtually exclude species such as *Cellana* and *Chamaesipho. Rivularia firma* occurs in this zone and *Gelidium pusillum* forms a marked band on the *Galeolaria. Modiolus pulex* and *Brachidontes rostratus* (Dunker) occur in crevices but neither are abundant. *Kellia australis* (Lamarck) is found in the byssal threads of the *Brachidontes.*

(d) *Lower Eulittoral Zone:* In most positions this zone is neither well developed nor distinct from the immediate sub-littoral zone. Lithothamnia almost entirely cover the rock surface. *Patellanax peroni* is common and at lower levels *Poneroplax costata* and *P. albida* occur. *Hormosira banksii,* with some *Caulerpa brownii* and *Colpomenia sinuosa,* is common where there is local shelter and the rock surface is almost level. Below this there is a narrow but distinct band of *Cystophora torulosa* with occasional young *Zonaria* and *Laurencia* species. *Patiriella exigua* is recorded from this zone and as noted by Dartnall (1971) it is often closely associated with *Hormosira banksii. Dicathais textilosa* and *Montfortula rugosa* (Quoy et Gaimard) occur in crevices and also in the upper sub-littoral zone.

(e) *Upper Sub-Littoral Zone:* In positions of maximal wave action *Durvillea potatorum* is characteristically found at this level. Where offshore rocks or *Durvillea* provide shelter the upper sub-littoral zone is dominated by Fucales, in particular *Cystophora moniliformis* and *C. siliquosa* J. Agardh, and corallines. *Caulerpa brownii* is abundant with *C. obscura* on vertical faces and *C. vesiculifera* where waves suck back. Other species occurring under these conditions include: *Apjohnia laetevirens* Harvey, *Caulerpa geminata, Chaetomorpha darwinii, Dictyosphaeria sericea* Harvey, *Acrocarpia paniculata, Cystophora subfarcinata, Macrocystis angustifolia, Perithalia caudata, Phyllospora comosa, Sargassum decipiens* (R. Brown in Turner) J. Agardh, *S. heteromorphum* J. Agardh, *Seirococcus axillaris* (R. Brown ex Turner) Greville, *Xiphophora chondrophylla, Zonaria turneriana* J. Agardh, abundant young infertile *Zonaria* species, *Corallina officinalis, Haliptylon subulata, Laurencia elata,* lithothamnia, *Metagoniolithon charoides* (Lamouroux) Weber-van Bosse, *Plocamium angustum* and *P. costatum.* With even more shelter *Pterocladia capillacea* occurs and *Polysiphonia nigrita* Sonder is epiphytic on *Cystophora subfarcinata.* Where there is extreme local shelter the following species occur: *Caulerpa brownii, Caulocystis cephalornithos, Cystophora polycystidea* Areschoug ex J. Agardh, *C. subfarcinata, C. moniliformis,* (large, >1 m, bushy, branching), *Sargassum* species (subgenus *Arthrophycus*), some *Xiphophora chondrophylla* and abundant epiphytic corallines. *Heliocidaris erythrogramma* (Val) is common in rock depressions. Near the sewerage outfall at Currie large plants (up to 15 cm diameter) of *Colpomenia sinuosa* are common; similar observations are made near the Werribee sewerage farm in Port Phillip Bay, Victoria.

Many of the species recorded for this rough water coast are none the less indicative of shelter. Table 5 indicates the situation at Currie for the main zone forming organisms.

(ii) Moderate wave action, (site 3, East coast).

The maritime zone is dominated by grasses with some succulents and there is a sharp transition to bare granite some 5 m above high tide level. The orange lichen band (*Caloplaca*) characteristic of Tasmania and E. Bass Strait islands is well developed in contrast to other localities on King Is. This could be a substrate effect since a well developed *Caloplaca* band is often, though not invariably, developed on granite.

(a) *Littoral Fringe: Melarapha praetermissa* is confined to crevices and *Notoacmea mayi* and *N. petterdi* are not common. Towards the inner edge of the 'reef' *Bembicium nanum* dominates the zone with *Austrocochlea constricta* in pools. *Enteromorpha* and *Austrocochlea concamerata* occur particularly where there is fresh-water inflow.

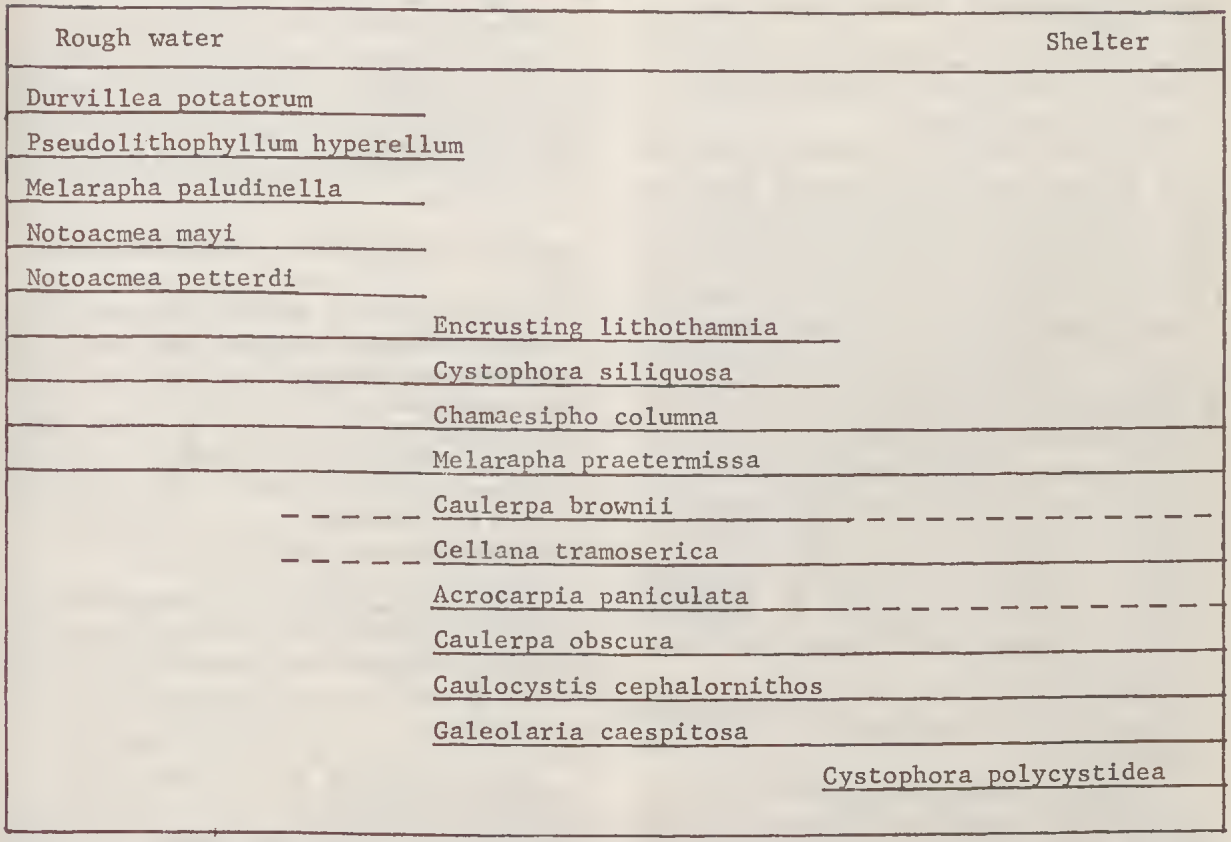
(b) *Upper Eulittoral Zone:* The pattern is similar to locally sheltered positions on the west coast. *Lichina confinis, Tetraclita purpurascens, Melanerita melanotragus* and *Siphonaria diemenensis* are common; *Siphonaria tasmanica* is absent. *Cellana tramoserica* occurs at this level but now extends through the entire eulittoral zone and *Chamaesipho columna* extends down to the *Hormosira* belt.

(c) *Mid-Eulittoral Zone: Galeolaria caespitosa* with epizoic *Gelidium pusillum* marks this zone with some *Rivularia firma* above. *Brachidontes rostratus* occurs in crevices but also in dense patches where flat or gently sloping rock surfaces occur above the *Galeolaria. Modiolus pulex* is restricted to crevices on the outer edge. Crevice pools at this level commonly contain *Actinea tenebrosa,* while larger pools support *Cystophora polycystidea* and *C. retorta* with *Caulocystis cephalornithos* occurring where there is sand.

(d) *Lower Eulittoral Zone: Hormosira banksii* completely dominates this zone except on the very outer edge where there is a lower sub-zone of *Cystophora torulosa.* Occasional *Codium fragile* (Suringar) Hariot, *Laurencia* species and chitons (*Poneroplax*) occur. Pools at this level are densely

TABLE 5

Distribution of some zone forming organisms with respect to local shelter at Currie, King Is.



filled with algae including *Caulerpa geminata, C. longifolia, C. simpliciuscula, Chaetomorpha darwinii, C. aerea, Cystophora subfarcinata, Hormosira* with epiphytic *Notheia anomala* Harvey et Bailey, *Amphiroa anceps, Corallina officinalis, Jania fastigiata, Haliptylon subulata, Plocamium augustum* and all of the species listed for the upper sublittoral zone.

(e) *Upper Sub-Littoral Zone:* This zone lies immediately below the *Cystophora torulosa* band but the division is less clear in rougher parts where the *C. torulosa* is scattered. *Cystophora moniliformis, C. siliquosa,* and *Caulerpa brownii* dominate with *Acrocarpia paniculatum, Macrocystis angustifolia, Perithalia caudata, Sargassum* species and *Xiphophora chondrophylla* present. *Haliptylon subulata* is a very common epiphyte.

Ecklonia radiata was not seen growing although it is abundant in the drift.

(iii) Sheltered open coast, (site 4, Naracoopa).

(a) *Littoral Fringe:* Upper zones are truncated by sand beach. *Caloplaca* is present on the rocks but not common. *Lichina confinis* forms a conspicuous zone on open rock and animals crowd the crevices. *Melarapha praetermissa* is abundant and *M. paludinella* is less common. *Melanarita melanotragus* is abundant into the upper eulittoral zone. *Notoacmea* species are absent.

(b) *Upper Eulittoral Zone: Chamaesipho columna* is present in both the upper and mid-eulittoral zones and covers up to 40% of open rock surfaces. *Tetraclita purpurascens* is common in shaded positions and crevices. *Siphonaria diemenensis* is abundant in the upper and mid-eulittoral zones and *Cellana tramoserica* occurs throughout the entire eulittoral zone. *Bembicium nanum* occurs in this zone slightly above *Austrocochlea constricta,* which is often in pools, and *A. concamerata,* in crevices. Occasional plants of *Ulva lactuca* and *Rivularia firma* occur at this level.

(c) *Mid-Eulittoral Zone: Cellana tramoserica* and *Chamaesipho columna* are spread throughout the zone and *Rivularia firma* is common above the *Galeolaria caespitosa,* which marks the lower limit of this belt. *Actinea tenebrosa* is common throughout the zone, and *Modiolus pulex,* with *Lepsiella vinosa,* occurs in the crevices. Pools at this level contain *Chaetomorpha aerea, Hormosira banksii*

with *Notheia anomala, Cystophora retorta* (Mertens) J. Agardh and stunted corallines. Deeper pools with sand contain *Codium fragile, Caulocystis cephalornithos* with epiphytic *Sphacelaria* species, *Cladostephus verticillatus* (Lightfoot) C. Agardh, and *Heterozostera tasmanica* (Martens ex Ascherson) den Hartog.

(d) *Lower Eulittoral Zone: Hormosira banksii* forms a dense band and *Laurencia tasmanica* Hooker et Harvey in Harvey is common. *Cystophora torulosa* forms a characteristic lower subzone with individual plants up to 1 m in length. *Patelloida alticostata* is common but *P. latistrigata* is rare. *Dicathais textilosa* is scattered throughout the zone. The flora of lower pools resembles that of the upper sub-littoral zone but with increased diversity. Species other than those recorded for the sub-littoral zone are *Callipsygma wilsonii* J. Agardh, *Caulerpa flexilis* Lamouroux, *C. obscura, C. scalpelliformis* (R. Brown in Turner) *C. Argardh, C. simpliciuscula, Codium galeatum* J. Agardh, *C. pomoides* J. Agardh, *Cystophora polycystidea, Pachydictyon paniculatum, Perithalia caudata, Sargassum* (sub-genus *Eusargassum*), *Zonaria turneriana, Jania fastigiata* and *Metagoniolithon charoides.*

Lenormandia prolifera (C. Agardh) J. Agardh is abundant in sandy pools where it is shaded by other algae.

(e) *Upper Sub-Littoral Zone: Xiphophora chondrophylla* forms a dense but narrow band (vertical range < 10 cm) and the encrusting coralline (MELU 20987) is commonly epiphytic. This band appears to be equivalent to the sub-littoral fringe of Womersley and Edmonds (1952). Below this, *Caulerpa brownii, Cystophora moniliformis* and *C. siliquosa* dominate and the entire rock surface is covered by encrusting lithothamnia. Other species present include *Caulerpa geminata, Acrocarpia paniculata, Cystophora subfarcinata* and *Sargassum heteromorphum. Polysiphonia nigrita, Haliptylon subulata* and *Jania* are common epiphytes. No *Phyllospora* or *Ecklonia* are recorded although both are found in the driftweed.

General Observations on the Marine Biota of Western Bass Strait

(i) The absence of some common zone-forming organisms is probably due to seasonal factors, e.g. *Splachnidium rugosum* is often used as an indicator of the mid-eulittoral zone but it is not recorded here since during winter the macroscopic plant form is absent (Price and Ducker, 1966).

(ii) There is a marked similarity between the intertidal zonation of sheltered positions on rough water coasts and sheltered open coasts. More species are found on rough water coasts because there is the possibility of a wider range of environmental conditions. Actual species density on King Is. is greater in sheltered positions.

(iii) *Notoacmea petterdi* is a common species on King Is. Bennett and Pope (1960: Fig. 3) regard it as common for the E. coast of Tasmania only but note that Kershaw (1958) records it for Stanley, N. Tasmania. Guiler (1960b) records *N. petterdi* for Trial Harbour on the W. Tasmanian coast.

Affinities of the Western Bass Strait Marine Biota

Plants. The affinites of the W. Bass Strait flora lie with the Victorian and Tasmanian regions. The most noticeable difference from the South Australian marine flora is the presence of *Cystophora torulosa* and the large brown kelps, *Durvillea potatorum, Macrocystis angustifolia* and *Phyllospora comosa.* Species present on King Is. but not recorded E. of Wilsons Promontory and in S. New South Wales include 9 siphonous green algae and 5 members of the order Fucales.

Animals. The common zone forming animals on King Is. are similar to those in W. Victoria and W. Tasmania. Barnacles are reduced both in the number of species and total number and *Chthamalus antennatus* is the only common species. A similar reduction is noted in S. Tasmania and is generally attributed to the lower air and sea temperatures. Similarly, the common littorinid on King Is. is *Melarapha praetermissa; Melarapha unifasciata* is absent and again this species is not found on the W. or S. Tasmanian coast.

CONCLUSIONS

The pattern of zonation exhibited on the Bass Strait islands is similar to that on the southern mainland and Tasmanian coasts. The zonation pattern is more easily discernible on the smooth granite faces of E. Bass Strait islands where the tidal range is approx. 2·5 m.

The most notable feature shared by the Bass Strait islands is the sub-littoral fringe. In rough water localities in E. Bass Strait no sub-littoral fringe can be biologically justified but in W. Bass Strait *Durvillea potatorum* forms a definite fringe as it does in Victoria and Tasmania. In sheltered positions on Deal Is. and King Is. the sub-littoral fringe is characterised by the brown alga *Xiphophora chondrophylla.* This situation is not encountered on the mainland although a similar situation is occupied by *X. gladiata* in Tasmania.

The composition of the zonation pattern in King Is. is similar to that on the W. Victorian and W. Tasmanian shores. Barnacles are reduced in the number of species and total numbers when

compared with the central Victorian region and, as a consequence limpets become prominent in the littoral zone. *Melarapha praetermissa* becomes the dominant littorinid and *M. unifasciata* is absent as in W. and S. Tasmania. Where conditions are suitable broad bands of mussels are developed. The dominant kelps in the upper sub-littoral are *Durvillea potatorum* and *Macrocystis angustifolia*, both species accepted as indicators of cool temperate conditions. *Ecklonia* and *Phyllospora* are found in the drift weed but are not common.

The Eastern Bass Strait islands are under a warmer water regime and the kelps in the upper sublittoral zone include *Ecklonia radiata* and *Phyllospora comosa* both of which are characteristic on S. New South Wales coasts. In spite of the absence of *Durvillea* a number of species, generally characteristic of cool temperate waters in SE. Australia, are present, e.g. *Caulerpa brownii, Cystophora torulosa, Xiphophora chondrophylla* and *Ballia callitricha*.

The differences between E. and W. Bass Strait marine biotas is probably due to the generally lower sea temperatures found in W. Bass Strait. Air temperatures might be expected to follow the same trend but insufficient data are available to establish this.

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DESCRIPTION OF PLATE 10

(UPPER) Zonation pattern on sloping granite. The upper dark band of *Splachnidium rugosum* is epizoic on *Catophragmus polymerus.* The darker lower band is *Balanus nigrescens* with epizoic *Corallina officinalis, Dasyopsis clavigera* and *Polysiphonia* sp. The dark lichen and blue-green algal band of the littoral fringe is visible in the background. (*Curtis Island, Feb. 1971*). (LOWER) Dense band of *Xiphophora chondrophylla* forming a sub-littoral fringe immediately above *Phyllospora comosa. Hormosira banksii* (a lower eulittoral zone species) is seen in the lower left corner. (*Garden Cove, Deal Island, Nov. 1969*).